MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

ETM7096 - MICROWAVE COMMUNICATION SYSTEMS

12 MARCH 2016
2:30 p.m - 5:30 p.m
(3 Hours)

INSTRUCTION TO STUDENT

1. This question paper consists of 10 pages (including the cover page) with **FIVE (5) questions** only.

2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) List TWO (2) advantages and TWO (2) disadvantages of microwave radio communication.

[4 Marks]

(b) Explain TWO (2) RF issues in dealing with operating at high frequencies.

[4 Marks]

(c) An RF signal with a power of 20 dBm is connected to a band pass filter with insertion loss of 5 dB, followed with an amplifier with power gain of 15 dB and finally with connected with a low pass filter with insertion loss of 2 dB. What are the RF power in mili-watt (mW) that will be measured at the band pass filter output, amplifier output and low pass filter output ?

[6 Marks]

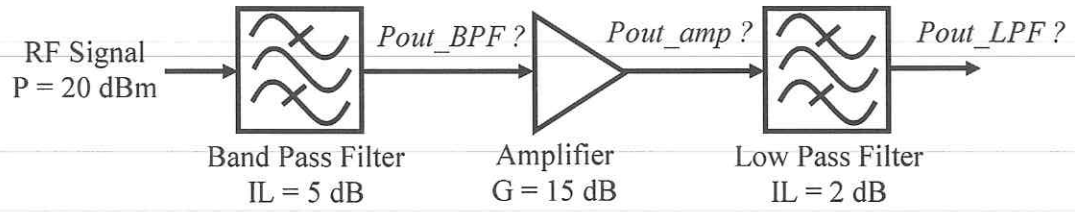

Figure Q1(c)

(d) Compute the Space Loss Ratio (*SLR*) for a 4 GHz terrestrial microwave link with tower spacing of 60 km. Given that the Effective Isotropic Radiated Power (*EIRP*) of the transmitter is 40 dBm, receiver antenna gain is 30 dB, noise temperature $T = 600$ K, and the bandwidth is 5 MHz. Compute the Signal-to-Noise ratio (*SNR*) in dB. (Boltzmann's constant, $k = 1.38 \times 10^{-23}$ J/K)

[6 Marks]

Question 2

(a) State THREE (3) advantages and TWO (2) disadvantages of direct-conversion (homodyne) radio receiver over the single-conversion heterodyne receiver

[5 Marks]

(b) An IF signal with input power (P_{in}) of 10 dBm and frequency (F_{IF}) of 5 MHz is connected to a transmitter front-end shown in Figure Q2(b), with the given insertion loss (*IL*) and center frequency (F_c) of the filters, gain (*G*) of the amplifiers and conversion gain (*CG*) of the mixers.

(i) Name the type of transmitter architecture used in this system.

[1 Mark]

Continued....

(ii) Determine the IF power that will be measured at the first mixer output (P_{out_mixer1}, in mW).

[2 Marks]

(iii) The first local oscillator is using low or high LO injection ?

[1 Mark]

(iv) List the frequencies after the first mixer output

[2 Marks]

(v) Determine the up-converted IF frequency after the first IF filter, F_{IF1}.

[1 Mark]

(vi) Determine the IF power that will be measured at the second mixer output (P_{out_mixer2}, in mW).

[2 Marks]

(vii) The second local oscillator is using low or high LO injection ?

[1 Mark]

(viii) List the frequencies after the second mixer output

[2 Marks]

(ix) Determine the up-converted RF frequency after the second RF filter, F_{RF}.

[1 Mark]

(x) Determine the RF power that will be measured at power amplifier output (P_{out_RF}, in mW).

[2 Marks]

(Note: Ignore the loss of connectors and assume all connectors are the same)

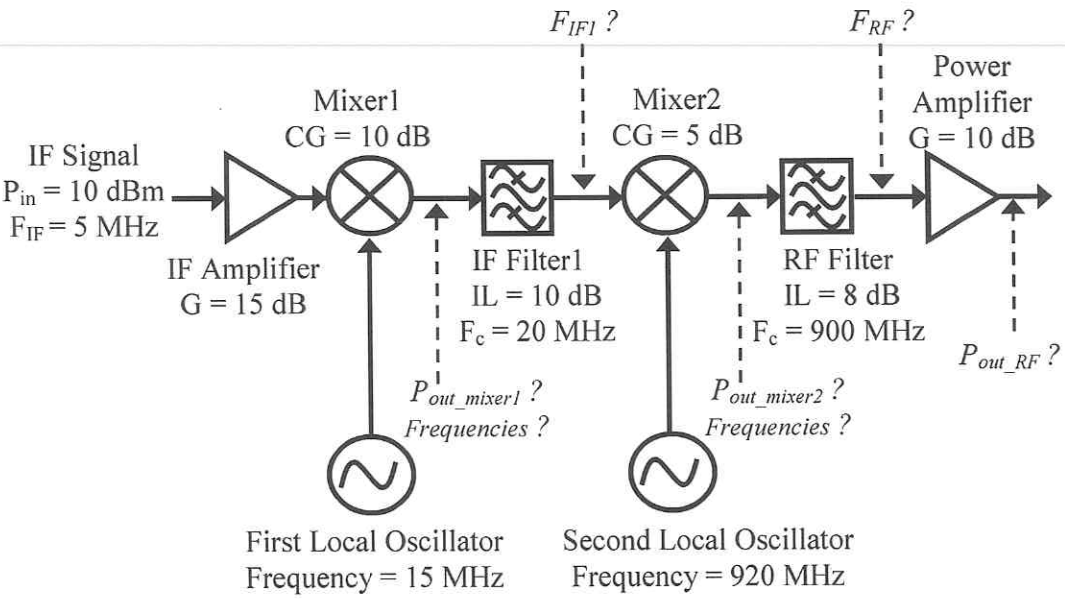
F_{IF1} ?
F_{RF} ?
Power Amplifier G = 10 dB
Mixer1 CG = 10 dB
Mixer2 CG = 5 dB
IF Signal P_{in} = 10 dBm F_{IF} = 5 MHz
IF Amplifier G = 15 dB
IF Filter1 IL = 10 dB F_c = 20 MHz
RF Filter IL = 8 dB F_c = 900 MHz
P_{out_RF} ?
P_{out_mixer1} ? Frequencies ?
P_{out_mixer2} ? Frequencies ?
First Local Oscillator Frequency = 15 MHz
Second Local Oscillator Frequency = 920 MHz

Figure Q2(b)

Continued....

Question 3

(a) List the three propagation modes in a waveguide/transmission line.

[3 Marks]

(b) Figure Q3(b) shows a cross section of microstrip transmission line printed on a Duroid substrate. The transmission line has a width of 1.0mm and the substrate thickness is 1.5mm.

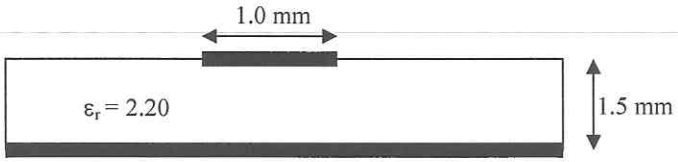

Figure Q3(b)

(i) What is the dominant mode of a microstrip line?

[2 Marks]

(ii) Determine the characteristic impedance (Z_c) and the effective dielectric constant (ε_{reff}) of the transmission line.

[4 Marks]

(iii) Calculate the per unit length of inductance (L) and capacitance (C) for this transmission line assuming that the line is lossless.

[4 Marks]

(iv) If the length of the microstrip line is 30mm, find the propagation delay of the line.

[2 Marks]

(v) If a load consisting of a 2.0nH inductor in series with a 330Ω resistance is connected to one end of this microstrip line, determine the load reflection coefficient and voltage-standing-wave-ratio (*VSWR*) at an operating frequency of 3000MHz.

[5 Marks]

Question 4

(a) Figure Q4(a) below shows a load made up of a 50Ω resistance, a 15nH inductance and a 22pF capacitance connected in series. The load is terminated to a two-wire transmission line with characteristics impedance of 50Ω. Determine the following using a Smith chart.

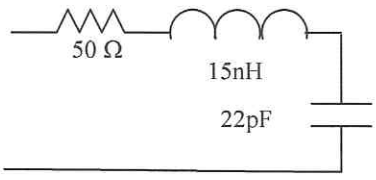

Figure Q4(a)

Continued....

(i) The load reflection coefficient at an operating frequency of 900 MHz.

[3 Marks]

(ii) Standing wave ratio on the transmission line.

[2 Marks]

(iii) The input impedance at 0.15λ away from the load, where λ is the wavelength at the operating frequency.

[4 Marks]

(b) State TWO (2) reasons why S-parameters are prefered over other parameters in describing a multi-port network at high frequency.

[2 Marks]

(c) Figure Q4(c) shows a two-port network made of three resistors. The ports' characteristic impedance is 50 Ω. Determine the scattering parameter for this network.

[9 Marks]

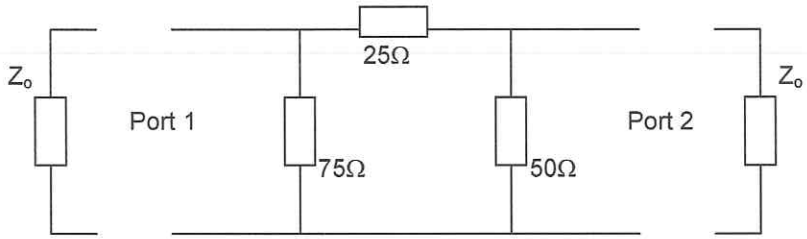

Figure Q4(c)

Question 5

(a) A filter has the S_{21} (in dB) shown in Figure Q5(a). It is measured from approximately DC to 1300 MHz, with a 50 Ω reference impedance (Z_0).

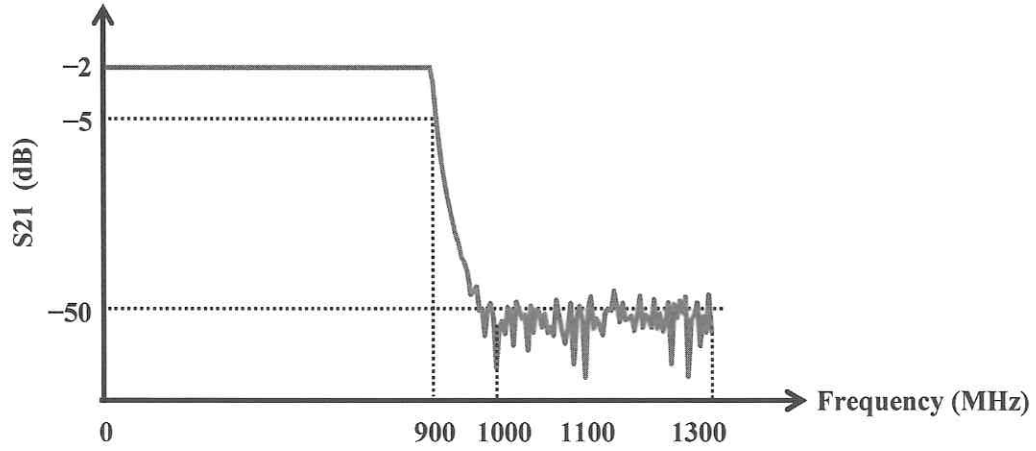

Figure Q5(a)

Continued....

(i) What type of filter is shown in the above measurement?

[1 Mark]

(ii) Determine the insertion loss and 3dB cut-off frequencies of the filter.

[2 Marks]

(iii) What are the stop-band frequencies and rejections of the filter?

[2 Marks]

(b) A device under test (DUT) has the following *S*-parameters at 1 GHz, with a 50 Ω reference impedance (Z_0) :

$$S_{11} = 0.01 \angle 0° = 0.01 + j0$$

$$S_{21} = 10 \angle 20° = 9.397 + j3.420$$

$$S_{12} = 0.05 \angle 10° = 0.049 + j0.0087$$

$$S_{22} = 0.02 \angle 0° = 0.02 + j0$$

(i) Determine the input impedance (Z_{in}) and output impedance (Z_{out}) of the above DUT.

[4 Marks]

(ii) Are the input and output of the above DUT matched to 50 Ω reference impedance? Justify your answer.

[1 Mark]

(iii) What are the input and output return losses of the above DUT in dB?

[4 Marks]

(iv) Is the above DUT has power gain or power loss? Justify your answer.

[2 Marks]

(v) What is the power gain or power loss of the above DUT in dB?

[2 Marks]

(vi) What is the isolation the above DUT in dB?

[2 Marks]

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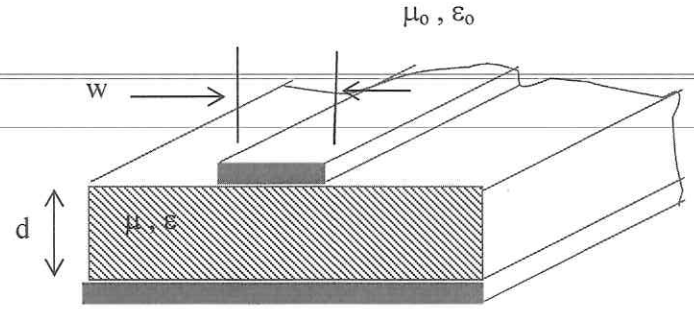
Appendix

A1. Microstrip transmission line equations



Effective dielectric constant, characteristic impedance and phase velocity:

$$\varepsilon_{eff} = 1 + \frac{\varepsilon_r - 1}{2}\left[1 + \frac{1}{\sqrt{1 + \frac{10d}{w}}}\right]$$

$$Z_c = \frac{377}{\sqrt{\varepsilon_{eff}}}\left[\frac{w}{d} + 1.98\left(\frac{w}{d}\right)^{0.172}\right]^{-1}$$

$$v_p = \frac{1}{\sqrt{\mu\varepsilon_{eff}\varepsilon_o}} = \frac{1}{\sqrt{LC}}$$

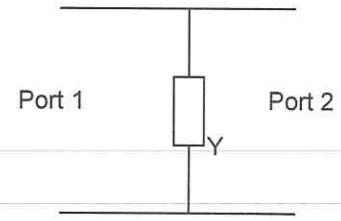
$$Z_c = \sqrt{\frac{L}{C}}$$

A2. General transmission line equations:

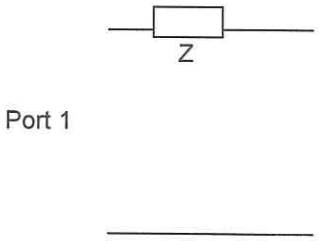
For a transmission line with characteristic impedance Z_o, terminated with load Z_L, the input impedance seen looking at a distance *l* away from the load is, where β is the phase constant.

$$Z_{in} = Z_o\left[\frac{Z_L + jZ_o \tan \beta l}{Z_o + jZ_L \tan \beta l}\right]$$

A3. Network transformation



For the above network the transmission parameters are: $A=1,\ B=0,\ C=Y,\ D=1$



For the above network the transmission parameters are: $A=1,\ B=Z,\ C=0,\ D=1$

Transformation from transmission (ABCD) parameters to S parameters:

$$S_{11}=\frac{A+B/Z_o-CZ_o-D}{A+B/Z_o+CZ_o+D}$$

$$S_{12}=\frac{2(AD-BC)}{A+B/Z_o+CZ_o+D}$$

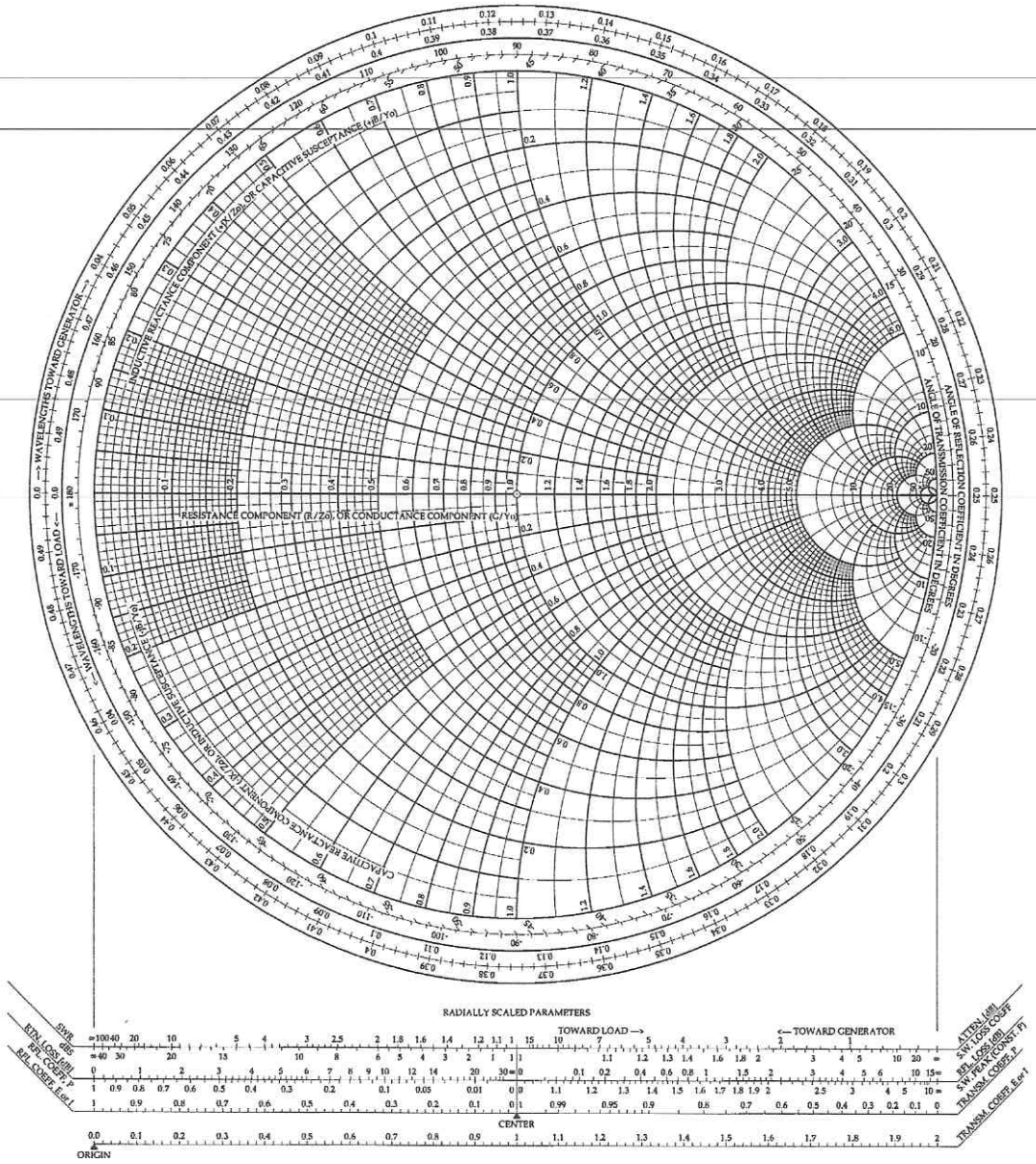
$$S_{21}=\frac{2}{A+B/Z_o+CZ_o+D}$$

$$S_{22}=\frac{-A+B/Z_o-CZ_o+D}{A+B/Z_o+CZ_o+D}$$

A4. Smith Chart

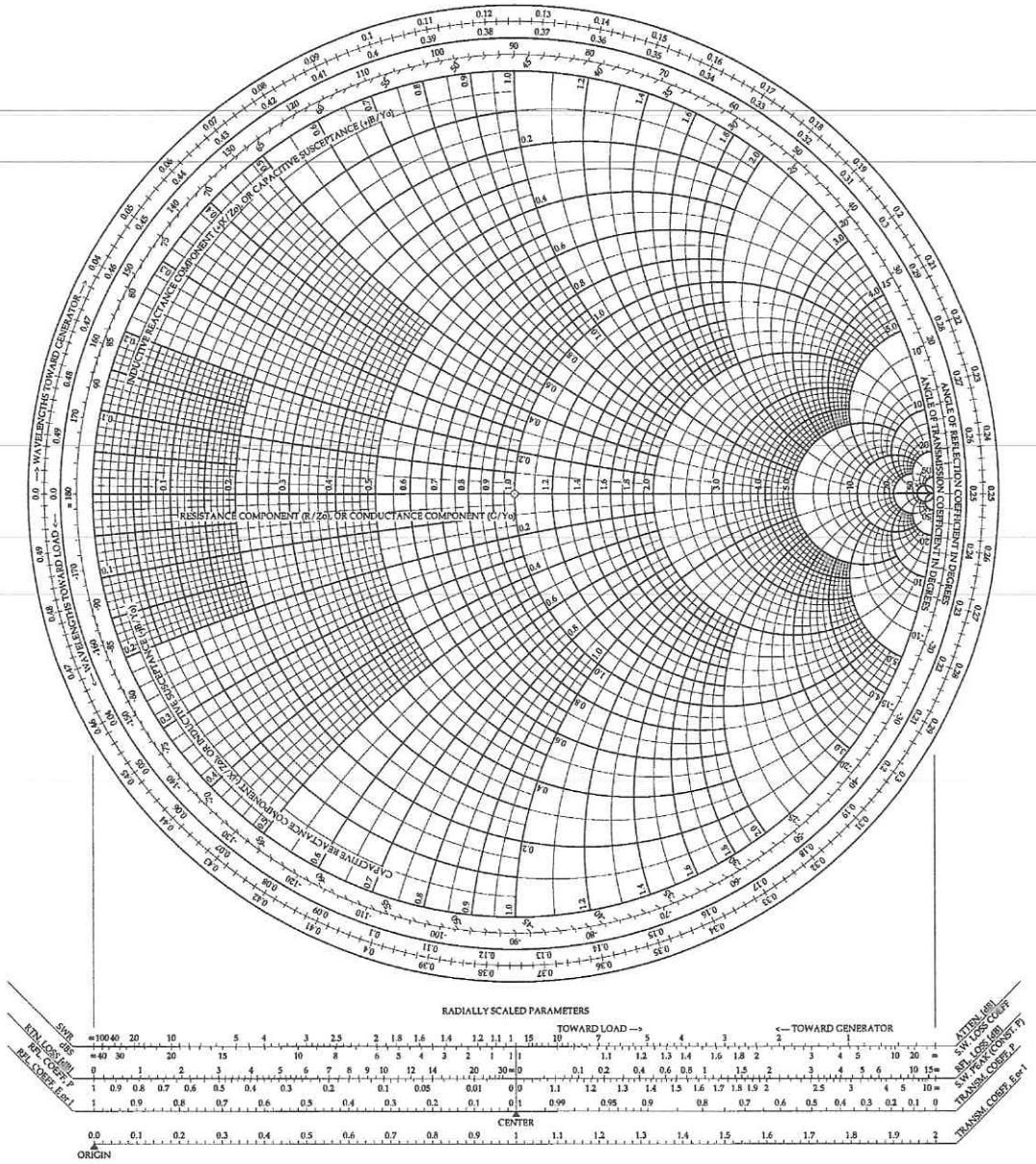
The Complete Smith Chart

Black Magic Design



The Complete Smith Chart

Black Magic Design


RESISTANCE COMPONENT (R/Zo) OR CONDUCTANCE COMPONENT (G/Yo)
INDUCTIVE REACTANCE COMPONENT (+jX/Zo) OR CAPACITIVE SUSCEPTANCE (+jB/Yo)
CAPACITIVE REACTANCE COMPONENT (-jX/Zo) OR INDUCTIVE SUSCEPTANCE (-jB/Yo)
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES
WAVELENGTHS TOWARD GENERATOR
WAVELENGTHS TOWARD LOAD
RADIALLY SCALED PARAMETERS
TOWARD LOAD
TOWARD GENERATOR
CENTER
ORIGIN